Space Weather Technical Forecast

Issued on Monday, 05 September 2022 at 00:15 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Chance of M-class flares (R1-R2 Blackouts). G1/G2 Minor/Moderate Geomagnetic Storm expected day 1 (5th).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity was Low with periods of C-class flares throughout, the largest being a C8.3 observed at 04/1638 UTC, originating from AR3089. There are currently five sunspots on the visible disc. The largest and most complex is AR3089, approaching the southwestern limb. This spot has shown some reduction in size and consolidation of it's intermediate region. The positive delta region within the largely negative trailing portion has also detached, therefore losing it's delta magnetic classification and is now classified as a Dki/Beta-Gamma configuration. All other remaining spots remain relatively small and simple, with no growth. A new and currently unnumbered sunspot has emerged in the southwest quadrant, but appears to be small and simple.

Solar Wind / Geomagnetic Activity: The solar wind, as measured by DSCOVR at L1, was indicative of a transition from one HSS into another stronger HSS, most likely from CH19/+ into CH20/+. The solar wind increased from 590 km/s, reaching a peak of 687 km/s at 04/1108 UTC, before declining to currently around 650 km/s. Density was average to above average with a peak of 19ppcc at 04/2157 UTC. Total interplanetary magnetic field strength (IMF), Bt, was mostly moderate throughout, with a peak of 13nT at 04/0147 UTC. The north-south component, Bz, was negative, with periods of moderate or weakly positive Bz during the 4th, with fluctuations between +8/-12 Bz. The Phi angle was almost entirely positive (away from the sun). Geomagnetic activity was stormy on September 4th, with intervals of successive G1/Minor, G2/Moderate and G3/Strong storms (Kp5, 6 and 7 respectively) were observed using BGS data.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV), as measured at GEOS-16 was at background levels. The high energy electron flux (greater than 2 MeV) was initially at background levels, before increasing to Moderate and High levels, with a peak of 6690 pfu at 04/1625 UTC. The 24-hour integrated electron fluence remained well below the Active threshold (1e8 integrated pfu) but displayed a rising trend, with 6.93e7 integrated pfu observed at 05/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to remain largely Low, with an ongoing chance of Moderate flares, mostly from AR3089. This spot will likely exert influence on the flare risk due to it's location until the end of day 3 (7th). A new region may rotate onto the northeast limb on day 1 (5th), potentially increasing the probabilities of significant flares.

Solar Wind / Geomagnetic Activity: The CME that left the sun on 2nd Sept may give Earth a glance on day 1 (5th). No other Earth-directed CMEs expected. Solar winds will initially be strong on day 1 (5th), gradually easing to elevated levels, although there is a slight chance of a brief rejuvenation due to a possible glancing blow from a CME. Solar winds should then fall back

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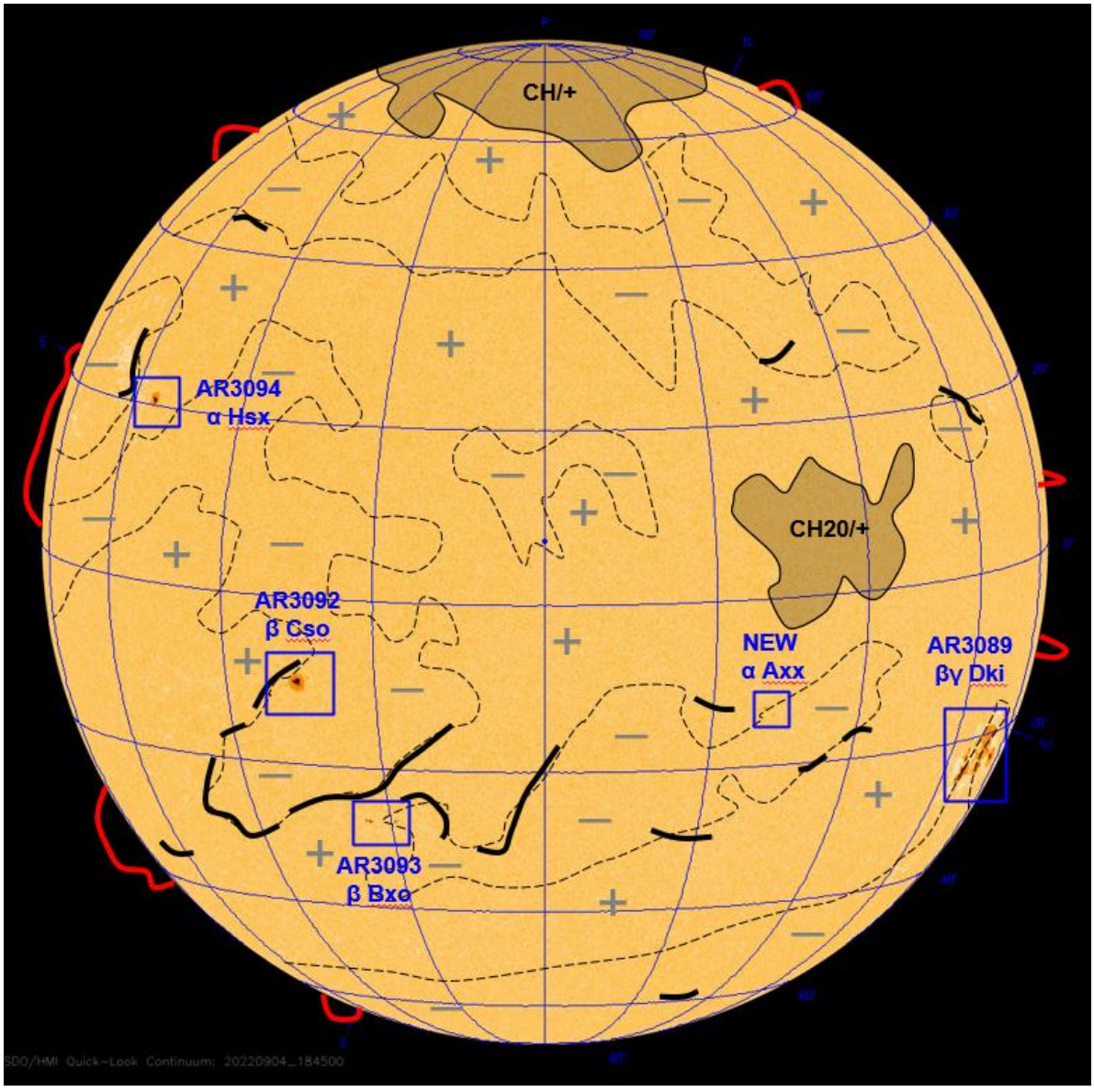
to slightly elevated by day 2 (6th) or day 3 (7th). Further periods of G1/Minor to G2/Moderate Geomagnetic Storms are expected on day 1 (5th), with a slight chance of further G3/Strong (Kp7) Storms. Geomagnetic activity should begin to reduce to Active to Unsettled into day 2 (6th), or perhaps day 3 (7th), before reducing to mostly Quiet or Unsettled by day 4 (8th).

Energetic Particles / Solar Radiation: High energy protons (greater than 10 MeV) are expected to remain below S1/Minor radiation storm levels. The high energy (greater than 2 MeV) electron flux is expected to rise erratically and become high over the following days. The corresponding 24 hour fluence is expected to display a sharp rising trend from day 1, with a chance of exceeding the Active threshold on day 1 (5th) then expected from day 2 (6th) onward.

Figure 1. Solar Analysis Valid 04/1845 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A marked filament eruption was observed leaving the sun on 2nd September. The CME that followed may give a glancing blow at Earth on day 1 (5th), with a possible arrival time around midday UTC. ENLIL suggests only a slight perturbation in the already elevated wind speeds on 5th Sept, this is considered to be good guidance with minimal overall impact at Earth above the already heightened baseline.

Solar winds are currently strong due to the HSS originating from CH20/+. Solar winds are expected to remain strong or elevated through the first half of the period before slightly declining as we exit the influence of CH20/+ during day 2 (6th). There remains uncertainty around a potentially complex region shortly following CH20/+ in the northern hemisphere. On the last rotation there was a large coronal hole following CH20/+ but currently there seems to be little evidence of this, therefore both ENLIL and SWPM may be artificially holding on to the higher solar wind speeds for an extended period.

Further periods of G1/Minor to G2/Moderate Geomagnetic Storms are expected on day 1 (5th), with a slight chance of further G3/Strong (Kp7) Storms. The baseline Geomagnetic activity should begin to reduce to Active to Unsettled into day 2 (6th), or perhaps day 3 (7th), before reducing to mostly Quiet or Unsettled by day 4 (8th).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	70	20	10	10
Strong	G3	No	5	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
03/0742	Nil	Filament Eruption	SE	750 km/s	05/1200 UTC	Glancing blow probable

Figure 2: ENLIL showing ongoing strong or elevated solar wind speeds due to CH20/+

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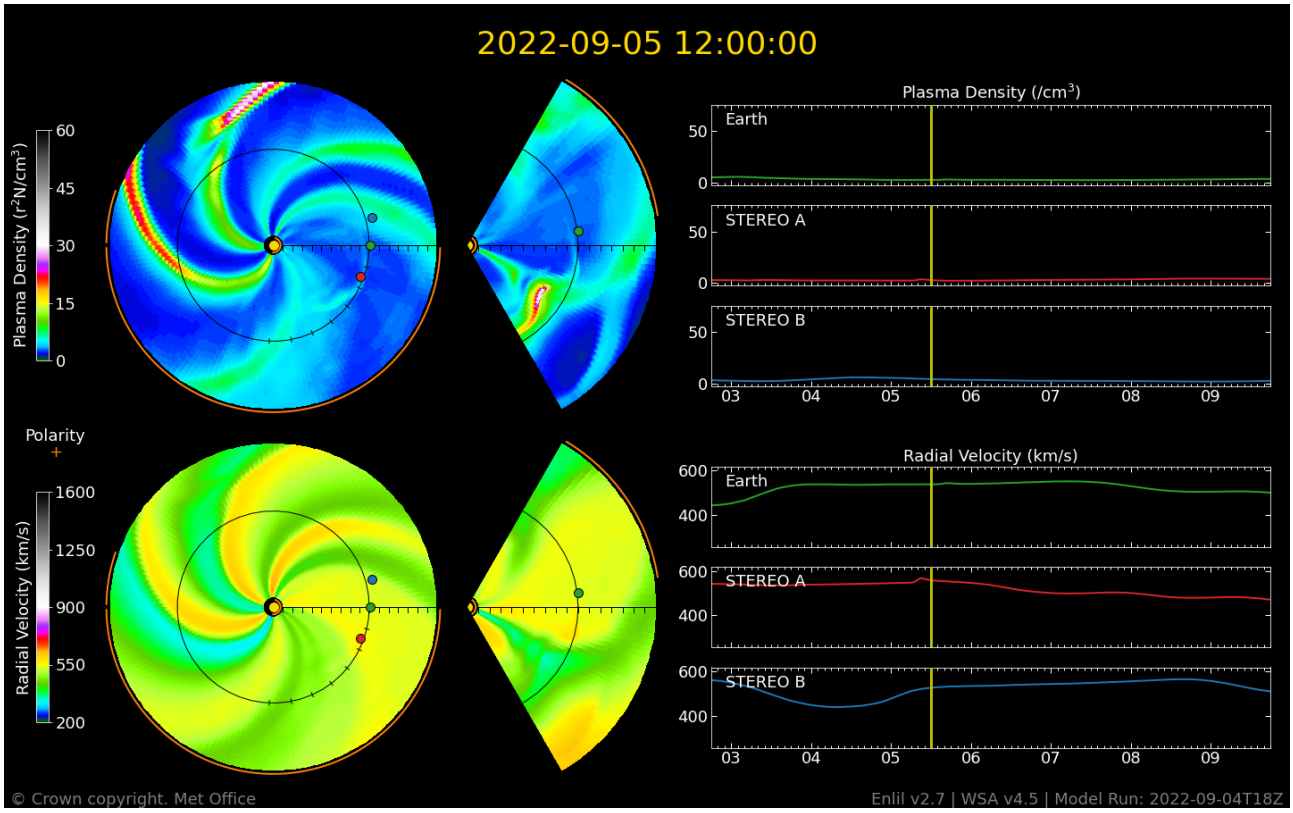
Space Weather Technical Forecast



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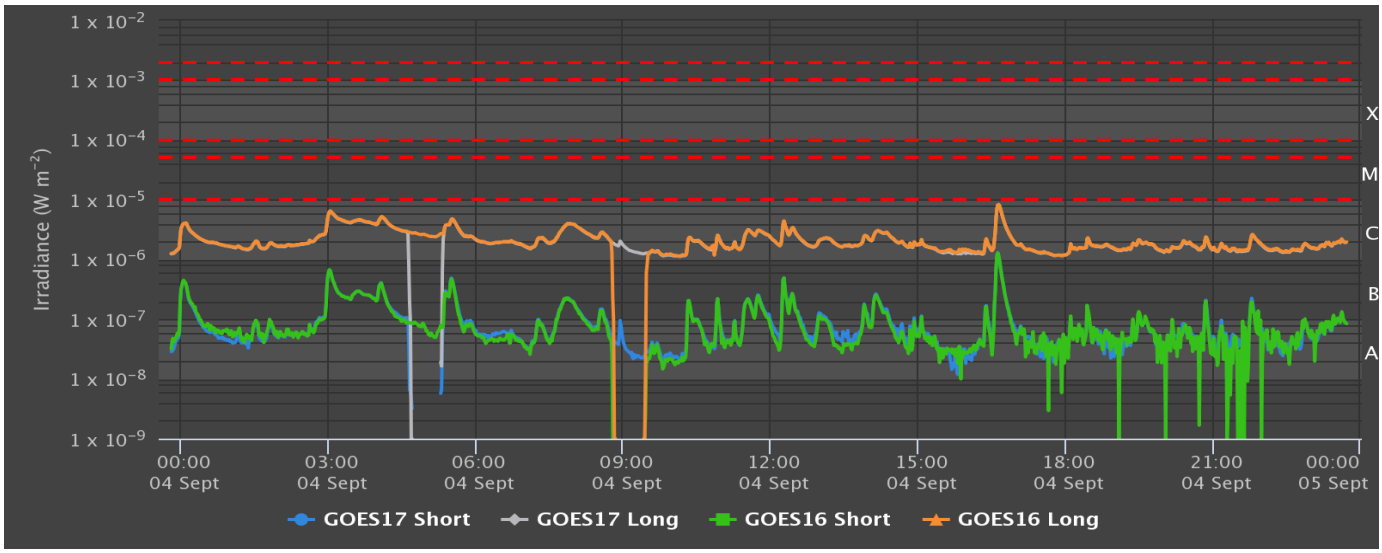
Radio Blackouts - X-Ray Flares:
There are five sunspot regions on the visible disc. The largest and most complex remains AR3089, which is approaching the southwest limb, which is becoming more difficult to analyse due to foreshortening. This region has reduced in size and appears to relatively stable, and only producing C-class flares. The positive delta region within the largely negative trailing portion has also detached, therefore losing it's delta magnetic classification and has been reclassified as a Dki/Beta-Gamma configuration. However, this region may give the chance of further M-class flares as it continues to rotate around the southwest limb in the coming days. All other remaining sunspots regions are all small and simple.

A large filament is visible in the southeast quadrant and will need to be monitored for any lift-off, particularly when it approaches the central meridian.

Solar activity is expected to remain largely Low, with an ongoing chance Moderate flares at times, mostly from AR3089. However the far-side solar map from Raben Systems, Inc indicates the presence of an active region approaching the northwest limb. It is currently not visible on the EUVI/AIA 195 imagery but may rotate onto the northeast limb at the end of day 1 (5th), potentially increasing the probabilities of significant flares.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	40	45	45	45
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: GOES-16 X Ray flares (top) and the SDO/AIA 94 image shows the C8 flare originating from AR3089



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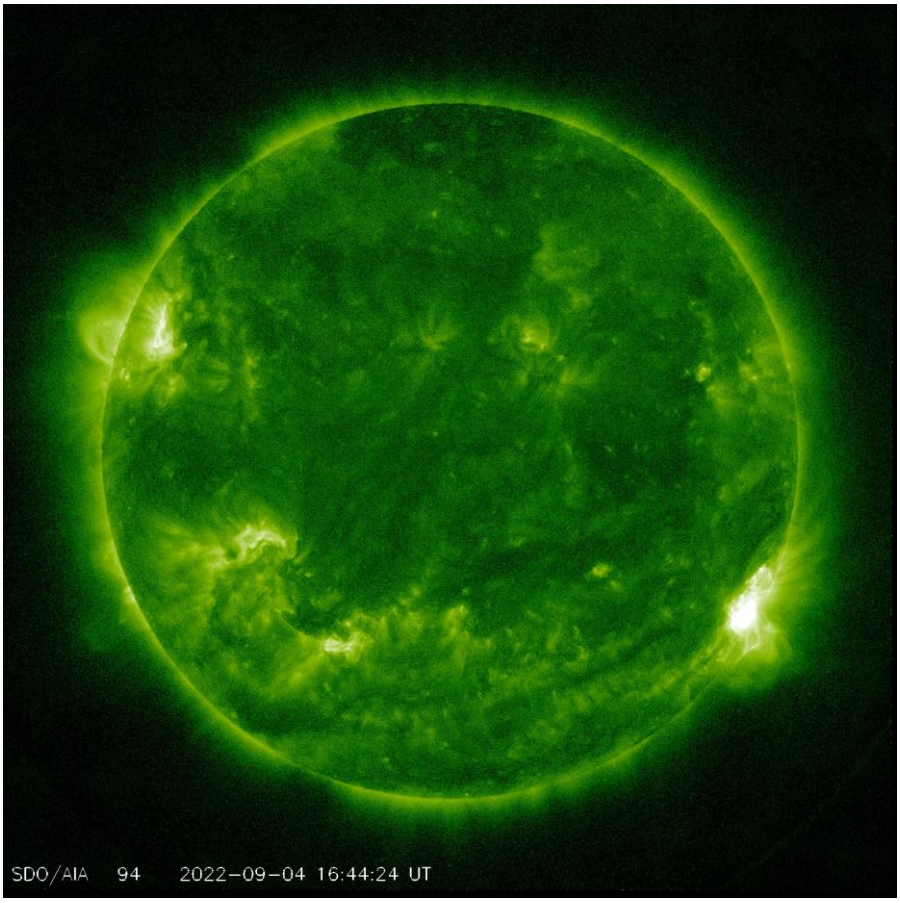

Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10MeV) remains at background values. Despite and apparent stability, AR3089 (Dki/Beta-Gamma) continues to present a slight chance of a proton event at Earth, should there be any significant flaring. This risk will continue as the region rotates further across the southwestern quadrant.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	3	3	3	3
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2 MeV) electron flux has become moderate to high, due to the recent enhancement from the fast speed streams originating from CH19/+ and CH20/+, recharging the Van Allen belts in electron populations. Flux levels are expected to continue to rise erratically during day 1 (5th), before comfortably remaining above high levels during days 2 to 4 (6th-8th).

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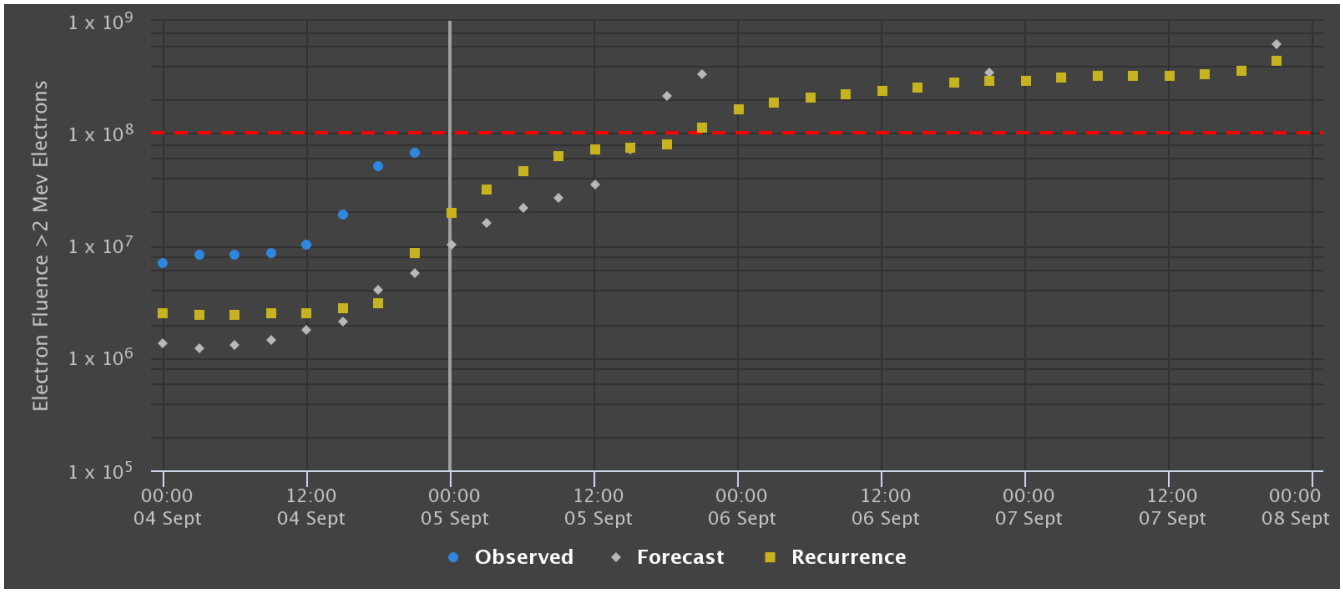
The corresponding 24-hour fluence is expected to continue displaying a rising trend, with a chance of exceeding the Active threshold from day 1 (5th) then expected from day 2 (6th) onward. This is supported the latest Met Office REFM output, although the model is currently slightly under-estimating fluence levels.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	40	70	70	70
Very Active	≥ 2 MeV ≥ $1x10^9$	No	5	10	20	20

Figure 4: REFM fluence observations, forecast and recurrence.



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